4. Our Role in NASA's Mission

NASA Enterprises and Priorities

The Laboratory for Atmospheres concentrates on two of NASA's four enterprises, the Earth Science Enterprise and the Space Science Enterprise. Table II presents all four of NASA's enterprises.

Table II: The Four NASA Enterprises

Earth Science Looks toward our planet to better understand the interactions of its system components and develop a capability to predict its future evolution.
Space Science Explores our star system and beyond to better understand the universe and the origin of life.
Human Exploration and Development of Space (HEDS) Expands the human presence beyond the Earth.
Aeronautics and Space Transportation Technology (ASTT) Develops and transfers innovative flight technologies.

Most Laboratory research corresponds to the five scientific areas of research identified as Earth Science priorities. Earth Science is NASA's contribution to the U.S. Global Change Program. Earth Science is an ambitious program designed to investigate the Earth as an integrated system. The program presents great scientific challenges and has important practical implications. Table III shows the research priorities for the Earth Science Enterprise (ESE). These priorities are being revised and updated. In addition, some of the activities will be transferred to a new Application Division created at NASA Headquarters.

Table III: NASA's Earth Science Priorities

Atmospheric Ozone
To detect and identify causes of atmospheric ozone changes and evaluate consequences.

Seasonal-to-Interannual Climate Prediction
To provide global observations and gain scientific understanding to improve forecasts of the timing and geographic extent of transient climate anomalies.

Long-Term Climate Variability
To provide global observations and gain scientific understanding of the mechanisms and factors which determine long-term climate variations and trends.

Land Cover Change and Global Productivity
To report and understand the trends and patterns of change in regional land-cover, biodiversity, and global primary production.

Natural Hazards
To apply Earth Science remote sensing science and technologies to disaster characterization and risk reduction from earthquakes, wildfires, volcanoes, floods, and droughts.

The Laboratory's space science activities address both of the fundamental questions raised by the Space Science Enterprise as seen in Table IV.

Table IV: NASA's Fundamental Space Science Questions

* How did the universe, galaxies, stars and planets form and evolve? How can our exploration of the universe and our solar system revolutionize our understanding of physics, chemistry and biology?
* Does life in any form, however simple or complex, carbon-based or other, exist elsewhere than on planet Earth? Are there Earth-like planets beyond our solar system?

Earth Science Activities

Laboratory scientists conduct basic and applied research in Earth system science, covering a broad range of atmospheric activity. Our work addresses both short-term weather forecasting and long-term climate studies. The wide array of Laboratory activities reflects Goddard's history of atmospheric research, from the early days of weather satellites and emphasis on weather forecasting to our present focus on global climate change. Several activities in the Laboratory support the operational satellite program of the National Oceanic and Atmospheric Administration (NOAA). Laboratory scientists serve as Project Scientists for the Polar Orbiting Environmental Satellite (POES) and the Geostationary Operational Environmental Satellite (GOES).

For ease of description, we can present the atmospheric science activities of the Laboratory in three groups: measurements, data products and data analysis, and modeling. This division is somewhat artificial, in that activities in one area often affect those in another. The groups are strongly interlinked and cut across science priorities and the organizational structure of the Laboratory. The grouping corresponds to the natural processes of carrying out scientific research: Ask the scientific question, identify the geophysical variable needed to answer the question, conceive the best instrument to measure the variable, analyze the data, and ask the next question.

Measurements

Experimental activities in the Laboratory are distributed throughout the Branches. Some instruments are *in situ* sensors that fly on balloons, aircraft, and planetary probes to sample the atmosphere locally. Other instruments are remote sensors that are deployed on the ground, aircraft, or satellites to observe the atmosphere over a broader range of space and time. The remote sensing instruments operate at a variety of wavelengths, from ultraviolet to microwave. They include passive sensors, measuring atmospheric scattering and emission, and active sensors, such as lidars and radars.

Laboratory scientists pioneered the development of the backscatter ultraviolet technique in the 1960s that led to the development of the widely known TOMS instrument. This technology is being employed to develop the next generation of passive remote sensing instruments to make observations from space. The lidar techniques are evolving from primarily ground- and aircraft-based instruments to Shuttle and free-flying satellites to measure clouds, aerosols, and atmospheric winds. Future applications include the measurement of atmospheric chemical constituents.

Data Products and Data Analysis

The Laboratory for Atmospheres devotes substantial resources to reducing raw, instrumental data into useful geophysical parameters, and analyzing data collected by sensors all over the world, including data from field campaigns and satellite missions.

Laboratory activities in the area of data products involve developing improved formulas for extracting new information from old data and assimilating data from multiple sensors to produce homogeneous data sets. These Data Assimilation Office (DAO) products are in heavy demand from scientists all over the world, as the products allow scientists to interpolate reasonable values in regions where observational data are lacking.

Some of the research areas with which the Laboratory has involvement in data products and data analysis are as follows:

Climate Variability and Global Change

We use advanced analysis techniques to identify natural variability on seasonal, annual, and decadal scales, and to isolate the natural variability from changes caused by humankind. The data analysis will be carried out in conjunction with modeling studies for physical interpretation and hypothesis testing. Satellite and remote sensing data are of primary importance. Other helpful data include those from ground observations, ocean arrays, aircraft, and measurement platforms in field campaigns.

Regional Climate Variability

Studies of regional climate variability help to link global climate information with societal needs. Developing this link is a major priority recommended by the Intergovernmental Panel on Climate Change (IPCC). In the Laboratory, this effort is just beginning.

We have conducted observational and modeling studies of precipitation, river run-off, fresh water fluxes, and related hydrologic processes for various climatic regions of the world. These observational studies provide benchmarks and working hypotheses for simulations and validation studies using regional climate models.

Atmospheric Ozone Research

Ozone affects life on the Earth in both harmful and helpful ways. Ozone in the troposphere contributes to smog formation and can therefore have bad effects on the biosphere. However, ozone in the stratosphere acts as a protective shield, preventing harmful ultraviolet (UV) radiation from reaching lower altitudes, where such radiation could damage genetic material.

We combine meteorological data with data from many ground, aircraft, and satellite missions to understand the factors that influence the production and loss of atmospheric ozone.

Aerosols/Cloud Climate Interactions

Extensive studies are underway on the optical properties of aerosols and their effectiveness as cloud condensation nuclei. We're analyzing a variety of data from satellite and experimental campaigns to assess the direct and indirect effects of aerosols on climate.

Water Vapor and Clouds

We've used multisensor observations to study moisture and water droplet distributions. Analysis of aircraft data shows the potential for contrail cirrus as a human-made factor in climate change. Studies are underway to determine the overall effect of aircraft-generated cirrus on climate.

Rain Measurements from Space

Laboratory scientists have been involved in measuring rain rates from data gathered from space and on the ground. The retrieved fields are analyzed on scales from local weather systems through regional and global climate scales. These analyses are essential to better understand the global hydrologic cycle.

Modeling Studies

To support the overall goals of Earth Science, scientists in the Laboratory develop a variety of computer models to understand historical changes in the atmosphere and to predict its future state in response to both natural and human-made disturbances. Models play an essential role in the interplay between observations and interpretations of atmospheric behavior.

Atmospheric models are being developed and used in the following areas:

Cloud Resolving Models

Two- and three-dimensional cloud and regional scale models are used to study classical meteorological phenomena. Such phenomena include convective systems in the tropics and in mid-latitudes, transport of aerosols and trace gases, stratospheric-tropospheric exchange, and air-sea interactions and their effect on clouds and climate. Cloud models are an intrinsic part of developing retrieval techniques designed to make maximum use of data that will be produced by the TRMM mission. Regional models are also used to develop and test parameters to be applied in General Circulation Models (GCM) and to understand regional-scale hydrological cycle physical processes.

General Circulation Models

GCMs are essential tools for studying atmospheric phenomena on seasonal, annual, and decadal scales, and for isolating natural variability from global change caused by humankind. In collaboration with the Laboratory for Hydrospheric Processes, the Laboratory for Atmospheres devotes substantial efforts to studying the El Niño Southern Oscillation (ENSO). We aim to assess the influence of satellite data on our ability to study and predict this phenomenon. We devote particular attention to developing parameterization codes for radiation and moisture processes. These processes play an essential role in determining climate sensitivities to cloud microphysics, water vapor, and other trace gases. They also significantly influence the global water and energy cycles.

Regional Climate Models

GCMs can now provide reasonably reliable results on global and continental time scales for simulating sub-continental- and sub-synoptic-scale climate variabilities. Improved simulation and prediction of local features are needed for regional-scale impact assessments of climate change. These inadequacies can be addressed with Regional Climate Models (RCMs).

RCMs generally consist of limited-domain mesoscale (10-50 km resolution) models nested within GCMs (100-500 km resolution) and/or global, four-dimensional assimilated data. For more detailed processes, a cloud resolving (1-2 km resolution) model can be further nested in the mesoscale domain. Nested RCMs can be used to model detailed atmospheric processes and interactions with the Earth's surface, using the large-scale conditions provided by GCMs or four-dimensional data assimilation. Regional Climate Modeling is a rapidly maturing effort in the Laboratory.

Trace Gas Modeling

Trace gas models simulate the short- and long-term behavior of atmospheric ozone in response to natural and human-made influences. Models differ in the ways they account for transport processes, the chemical reactions between the various atmospheric constituents, and the coupling between these processes.

Space Science Research

Laboratory instruments on the Atmosphere Explorers, Dynamics Explorer, Pioneer Venus Orbiter, and the Galileo missions have measured ion and neutral gas composition, neutral gas temperature and wind, and electron temperature and density.

Laboratory for Atmospheres scientists have just completed work on the Gas Chromatograph Mass Spectrometer (GCMS) to measure the chemical composition of gases and aerosols in the atmosphere of Titan, and on the Ion and Neutral Mass Spectrometer (INMS) to measure the chemical composition of positive and negative ions and neutral species in the inner magnetosphere of Saturn and in the vicinity of the icy satellites. Both instruments are flying on the Cassini mission. Work was completed on a NMS to measure the neutral atmosphere of Mars. That instrument is being flown on a joint mission with Japan called "NOZOMI." Arrival time is December 2003.

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